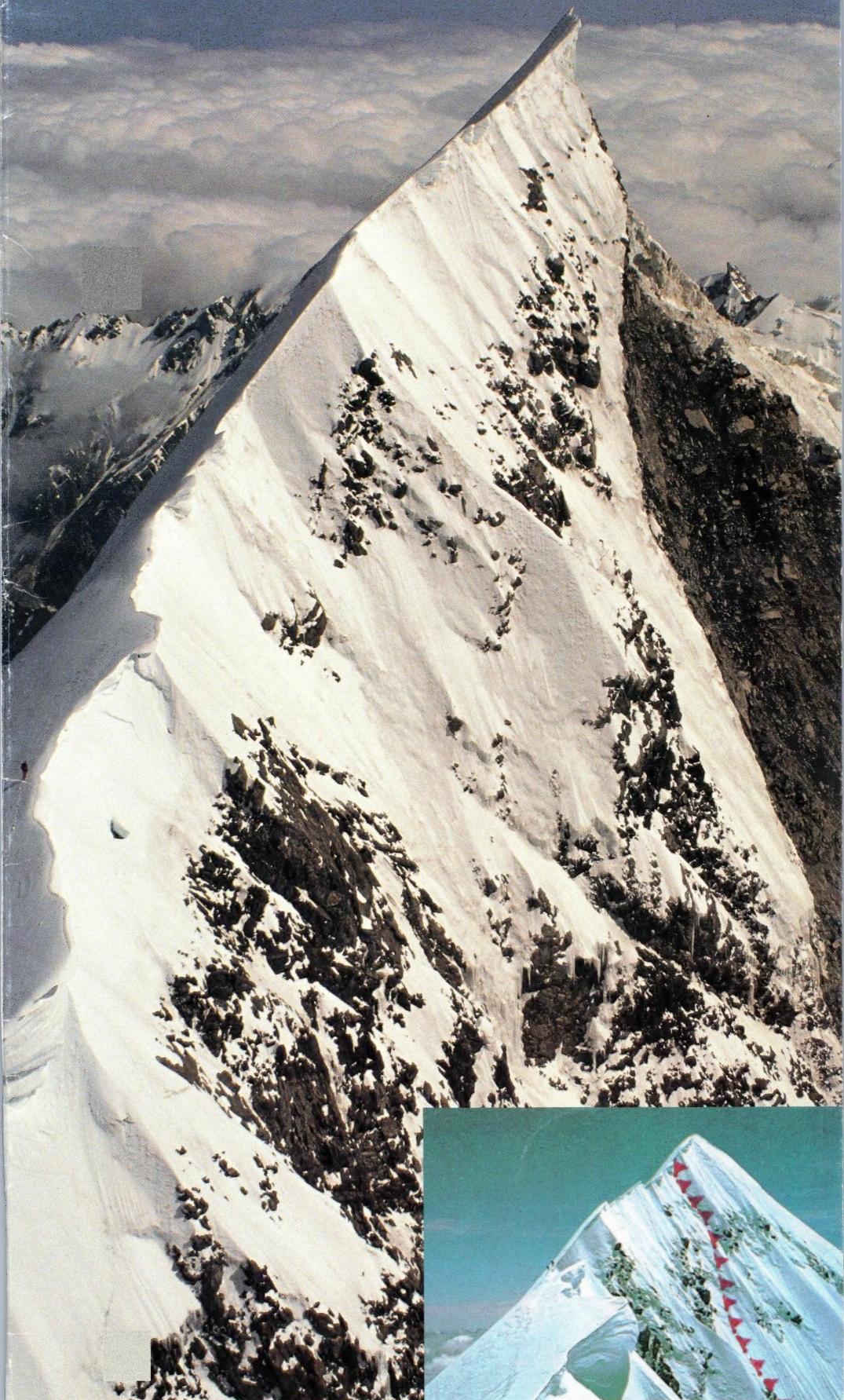


The Mount Cook Rock Avalanche of 14 December, 1991



A lone climber, Brian Moore (lower left) on January 2, 1992 is the first to ascend the new highest point in New Zealand (*Photo: M.J. McSaveney*), now a 20-metre shorter, but more precarious climb than before the rock avalanche (inset shows the former summit).

BEFORE



BEFORE

On the imposing East Face of Mount Cook, a 700-m high rock buttress formerly led up the High Peak (3764 m). Outlined is the 500-m wide source of the 14 December rock avalanche, whose collapse took the buttress and part of the summit with it (*Photo above: C. Monteath, June 1984*).

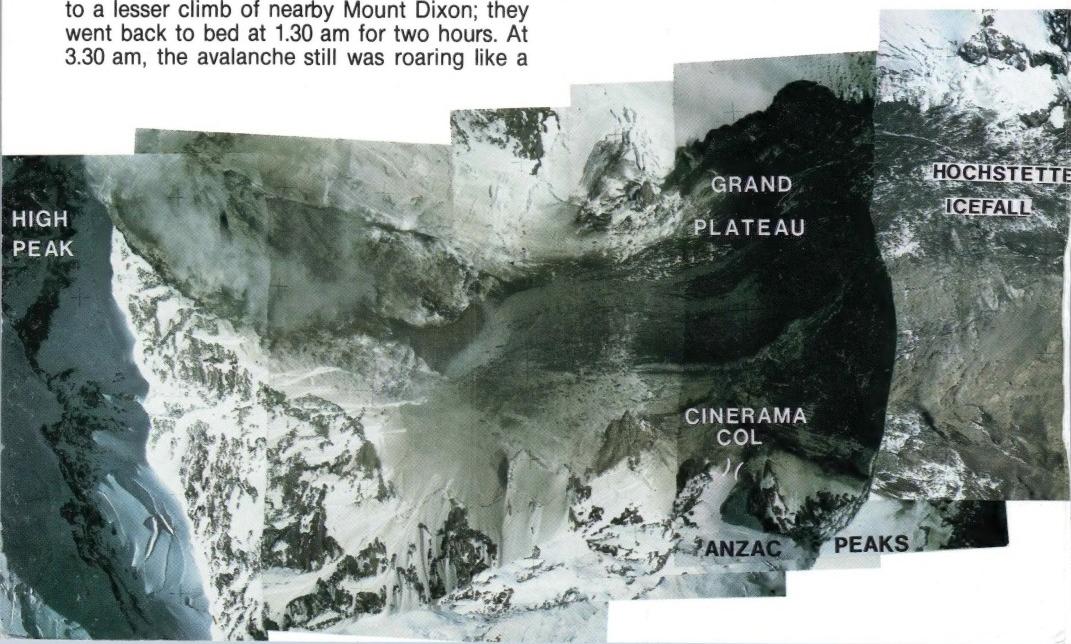
DURING

Climbing parties at Plateau Hut witnessed the avalanche from across the Grand Plateau. One party, rising shortly after midnight to prepare for a climb of Cook via Zurbiggen Ridge, were alerted in the dark by a loud rumble. Still shaking off the stupor of sleep, Rob Hall thought, "Damn! It's windy! ... That's not wind! ... It's a big icefall in the Hochstetter! ... A bloody big icefall!" Through a window they saw bright orange sparks of rock impacts flashing high up the East Face of Cook. It was a tremendous rockfall. A roar, likened to that of a huge and swiftly flowing river, continued unabated while they watched for an hour and a half. They abandoned all thought of climbing Cook — their access across the Grand Plateau gone, only 2 hours before they would have been on it. Their plans changed to a lesser climb of nearby Mount Dixon; they went back to bed at 1.30 am for two hours. At 3.30 am, the avalanche still was roaring like a

river. A light layer of dust had settled over the hut. They left for Dixon at 5 am, as the noise dwindled to spasmodic outbursts. Dawn breaking during their ascent revealed the enormity of the event they had almost become a part of. A great rock avalanche had plummeted down a seven-kilometre path. It crossed the Grand Plateau to within 300 m of Plateau Hut before turning down the Hochstetter Icefall. Rubble was spread to the far valley wall across the Tasman Glacier. New Zealand's highest peak now was a little lower. Had the fall occurred in daylight, it might have looked similar to the view simulated here.

AFTER

The snowfields of the Grand Plateau lie blackened, blanketed by the rubble of Mount Cook. The apparent devastation is only temporary, for the area is above the permanent snowline and snow will bury the dust and debris. Winter also will plaster a veneer of snow and ice across the bare rock of the East Face, but it will be years before glacier ice flows from the scar (*Photo right: T.J. Chinn, 17 Dec. 1991*).



DURING

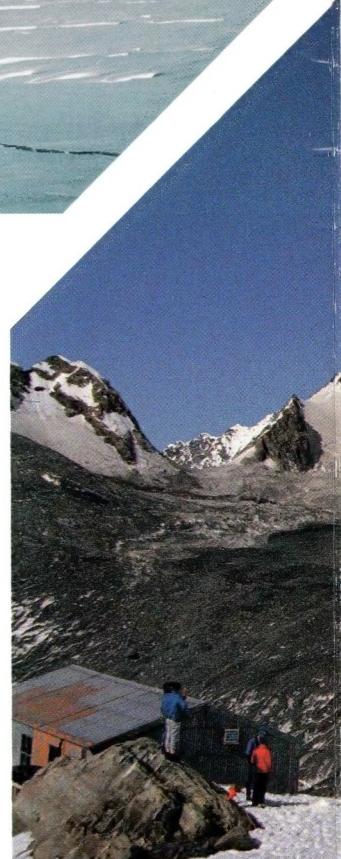


EXTENT

A mosaic of vertical aerial photographs (below) of the Mount Cook rock avalanche taken about 80 hours after the fall reveals the extent of the devastation. Dust from rockfalls obscures detail of the source area. Flowlines in the moving avalanche are caught frozen in the debris as it came to rest. Mount Cook's High Peak is 2.7 km closer to the camera than is the Tasman Glacier, so scale changes greatly across this view. The scar is about 500 m wide, while the avalanche lobe on the Tasman Glacier is 2 km wide (Photos: D.L. Homer).

WHY DID IT FALL?

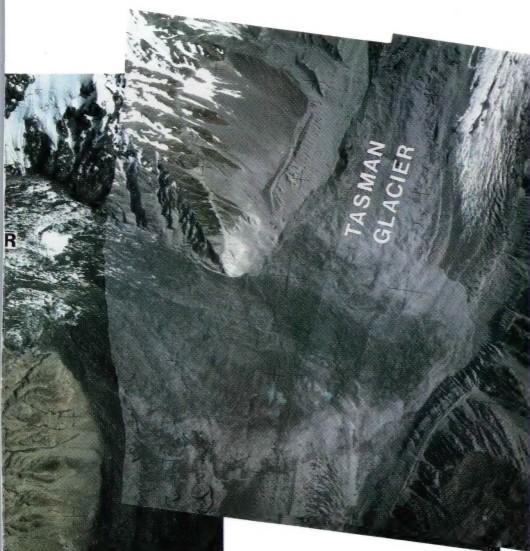
Rockfalls and rock avalanches are common in glaciated alpine areas. Evidence of their regular occurrence lies in numerous bouldery heaps below steep rocky slopes. Erosion by glaciers progressively steepens the adjacent mountain sides. The steep slopes may remain precariously unstable for many years until they give way, triggered by an earthquake or a storm. The Mount Cook rock avalanche, however, hap-



pened on a clear night, and seismographs recorded no earthquake in the area before the avalanche started. Why did it fall?

The face certainly has been unstable for a long time: it still is very precarious. The entire Mount Cook massif probably is unstable, with a large rock avalanche from the mountain's southwestern flank in 1873, and another from Mount Vancouver on its northern flank in 1974. We will never know why the latest one did not fall during the shaking of an earthquake, such as the magnitude 6.1 earthquake just 25 km away in the vicinity of Godley Glacier in 1984.

One possible answer to the puzzle may lie in movements of steep hanging glaciers clinging to the flanks of the mountain. These slowly creeping glaciers scour and pluck the underlying rock. Movement or a fall of ice from one of them, taking with it a critical piece of rock — the "chock stone" — supporting the otherwise unstable buttress, may have triggered the collapse. But, if it did, the evidence perished in the first moments of the fall.



The avalanche scar now is the steepest face on the mountain, and the exposed rock is very broken up, with wide, open fractures. The stage is set for another big rock avalanche, but we cannot predict when this dramatic act will be replayed.

SIZE AND SPEED

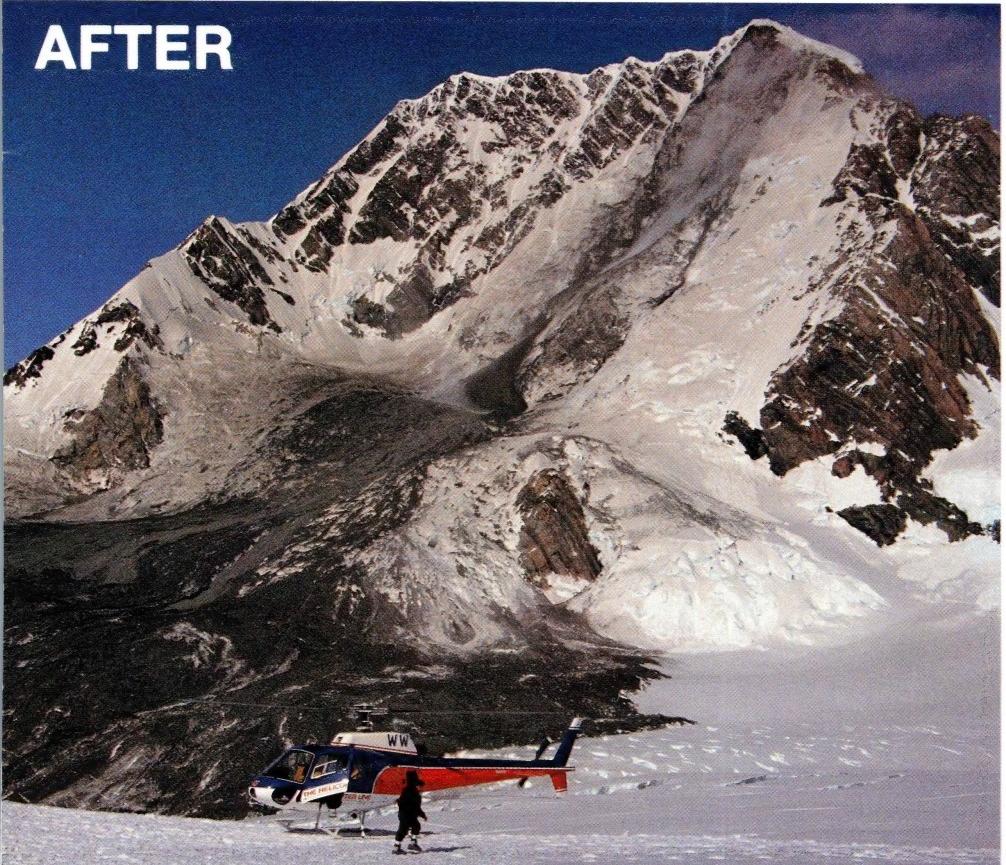
Whatever set it in motion, the estimated 14 million cubic metres of rock buttress and flanking glaciers quickly gathered speed. The disintegrating mass cascaded down the steep 57° slope. By the middle of the Grand Plateau it had reached perhaps several hundred kilometres per hour, enough to carry part of it over the lowest of the Anzac Peaks. Once moving, the collapsing mountainside behaved as a fluid, flowing an extraordinary distance. The debris flowed out across the crevassed area at the head of the Hochstetter Icefall, spreading over 1.5 km, from Cinerama Col almost to Plateau Hut. Most of the avalanche funnelled down the icefall, perhaps doubling speed on the steep slope to 400–600 km per hour. At the foot of the icefall it began to slow, spreading to a width of two

The avalanche picked up an amazing amount of snow and ice in its journey. Some came from glaciers clinging to the face, but the initial mass mostly was rock. Each cubic metre of rock gathered another 3 to 4 cubic metres of ice and snow, mainly snow of the past winter planed off the Grand Plateau névé. About 55 million cubic metres of pulverised rock and snow reached the Tasman Glacier, where the freshly fallen debris was only about 20% rock.

THE STUFF MOUNTAINS ARE MADE OF

Like many mountains in this area of the Southern Alps, Mount Cook is made of sedimentary rock called greywacke — very hard sandstone and siltstone — about 200 million years old. The fresh avalanche scar provided a unique opportunity to view the internal structure of the mountain beneath its icy carapace. Geologists were astounded to find it so pervasively fractured, and so obviously weak. Such loose shattered rock is referred to as "Weet-Bix" by New Zealand mountaineers. It is not because of the strength of its rock mass that Mount Cook is New Zealand's highest peak.

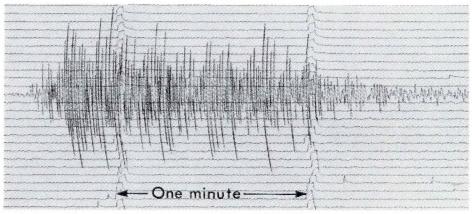
AFTER



kilometres. It crossed the broad Tasman Glacier, sloshing 70 metres up the far moraine wall, 7.3 km from the source area. The accompanying dust cloud rose 700 m up the side of the Malte Brun Range, and an air blast was felt 5 km away at Beetham Hut.

WAS THIS AN EXCEPTIONAL EVENT?

Large rock avalanches rank with volcanic eruptions as supreme examples of the awesome power of earth forces at work shaping the landscape. Like eruptions, they are not everyday events, and attract much public and scientific interest. In many respects this rock avalanche is little different from others known from the Southern Alps and around the world. The widespread devastation, the high speed, and the long distance travelled by the avalanche are common to many. The Mount Cook rock avalanche made a spectacular descent of 2720 m from the highest point of New Zealand (3764 m, 12,349 ft), lowering the High Peak by about 20 m.



SEISMIC SIGNATURE

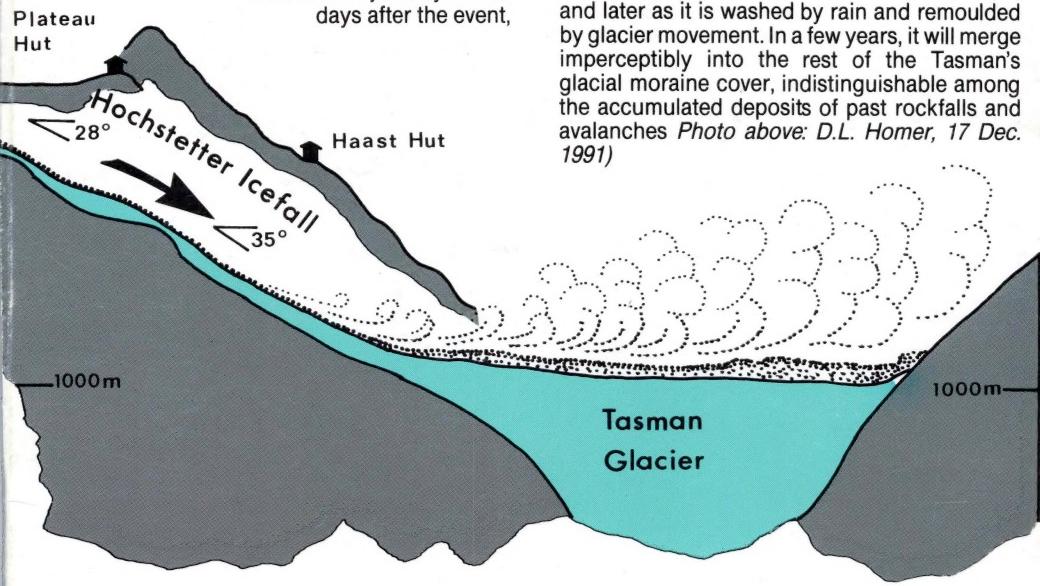
With no earthquake to obscure the record, the avalanche wrote a clear signature (above) on a seismograph at Twizel, 75 km away. Shock waves sent out by the collapsing mountain first reached Twizel about 12:11:20 am. They reached a crescendo equivalent to a magnitude 3.9 earthquake within 20 seconds. For about 70 seconds it was at full roar, before slowly dying away. Hours after, Twizel still was picking up a faint record of falling rocks. Other seismographs also recorded this distinctive signature, clearly placing its source at the scene of the avalanche. We infer an average speed of 300 km per hour from the signal duration.



THE DEPOSIT

The rock avalanche delivered a mantle of jumbled rock and ice rubble to the already debris-covered Tasman Glacier. Much of the rock (40%) was reduced to silt and sand. Many of the originally sharply angular rock and ice fragments were battered to rounded shapes in their violent journey. Three days after the event,

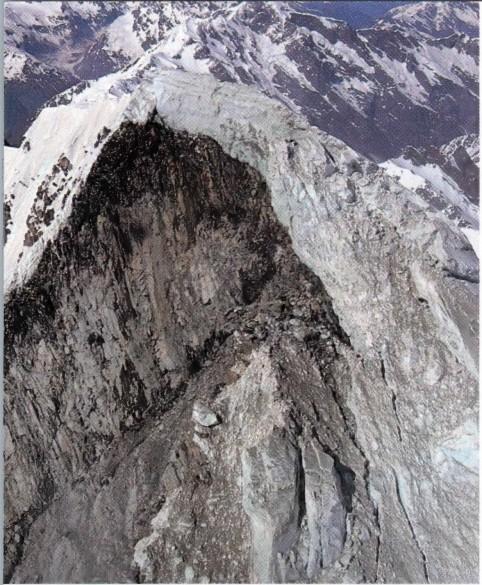
the debris superficially looked like grey, finely crushed rock. Beneath a thin blanket of sandy debris, from which the ice had melted, was a deposit consisting mostly of countless granules of last winter's snow from the Grand Plateau. Where ice was particularly abundant, the surface was dark and wet. The avalanche deposit will change quickly: first as its internal snow melts; and later as it is washed by rain and remoulded by glacier movement. In a few years, it will merge imperceptibly into the rest of the Tasman's glacial moraine cover, indistinguishable among the accumulated deposits of past rockfalls and avalanches Photo above: D.L. Homer, 17 Dec. 1991)



THE AIR BLAST

Beyond the limits of the debris, the Tasman Glacier was sprayed with mud and pebbles from a blast of air driven ahead of the rock avalanche. Warmed and melted by the compressing air as it descended some 2700 m, the ice-laden dust cloud blasted wet mud across the Tasman's rocky surface moraine. The speed of the blast is revealed by shadows of mud-free surface downwind of large boulders. One 1-m high boulder had a 2-m long shadow, suggesting a wind blast of about 400 km per hour. Not surprisingly, larger boulders were clean of the sticky mud. With the ephemeral evidence had vanished, buried into oblivion by rain (Photo left: D.L. Homer, 17 Dec 1991). \$3.50





THE GRAND PLATEAU

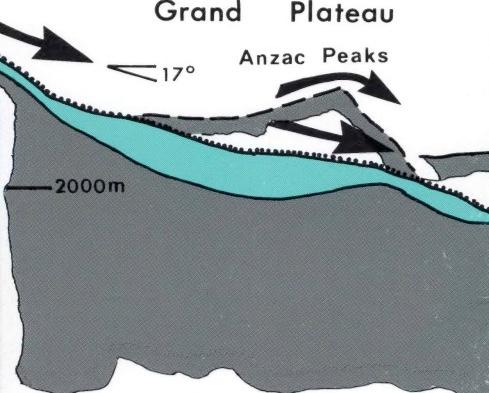
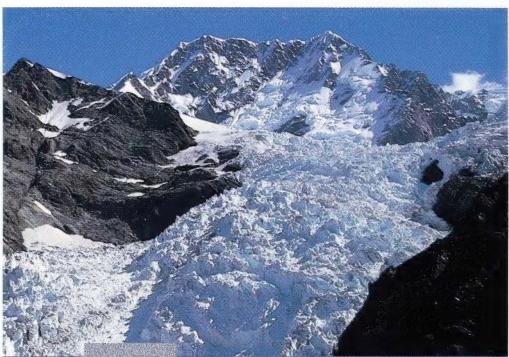
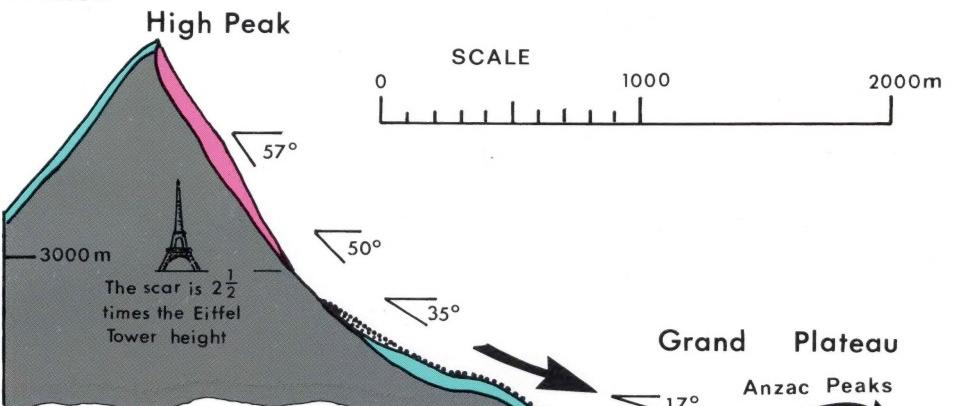
On the Grand Plateau, the avalanche slid across a snow-covered surface, bulldozing snow before it. The footprints of unknown climbers who crossed the Grand Plateau, perhaps only hours before the collapse, now lead beneath the blanket of finely pulverised rock and snow (Photo below: M.J. McSaveney, 17 Dec 1991).



THE UNSTABLE SUMMIT

The feather-edged slice of the 20-m thick summit icecap, shows layered ice lying on unstable fractured rock. Some fractures pass upward through both rock and ice, indicating very recent cracking (Photo above: T.J. Chinn, 17 Dec 1991).

— 4000 m



THE HOCHSTETTER ICEFALL BEFORE

The Hochstetter Icefall normally is a dangerous and impassable jumble of crevasses and towering ice pinnacles (Photo left: from Haast Hut, T.J. Chinn, March 1987).



AFTER

In one swift passage, the rock avalanche planed the chaotic ice surface of the Hochstetter Icefall to a steep and gravelly road. However the smoothed surface was very short lived. Within 3 days, crevasses had re-opened to 1 m wide, and ice avalanches were spilling clean ice over the debris. Glacier flow through the icefall will carry all of the debris away from the Grand Plateau in some 5 to 8 years (Photo left: T.J. Chinn, 17 Dec. 1991).



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